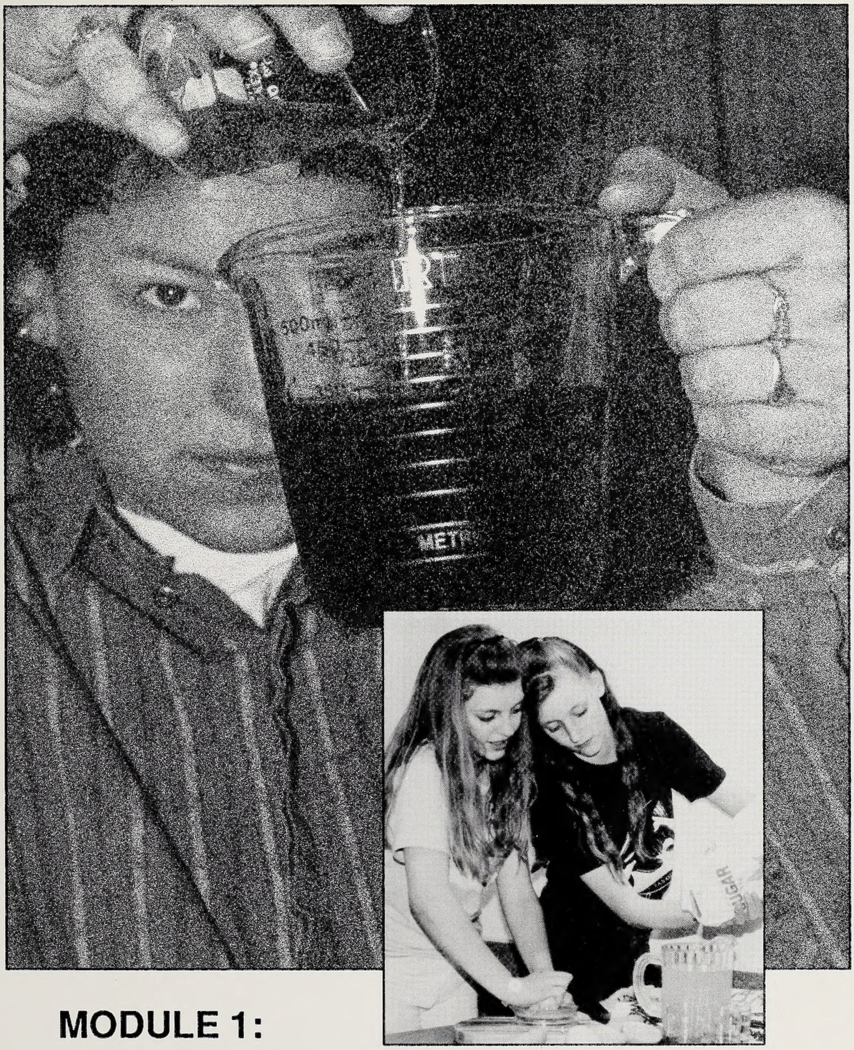
SCIENCE 8



MODULE 1:

Solutions and Substances

Distance Learning

Alberta
EDUCATION

Science 8

Module 1

SOLUTIONS AND SUBSTANCES

Distance Learning

Alberta EDUCATION

Science 8
Student Module
Module 1
Solutions and Substances
Alberta Distance Learning Centre
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Welcome to Science 8!

We hope you'll find this course interesting and fun.

To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

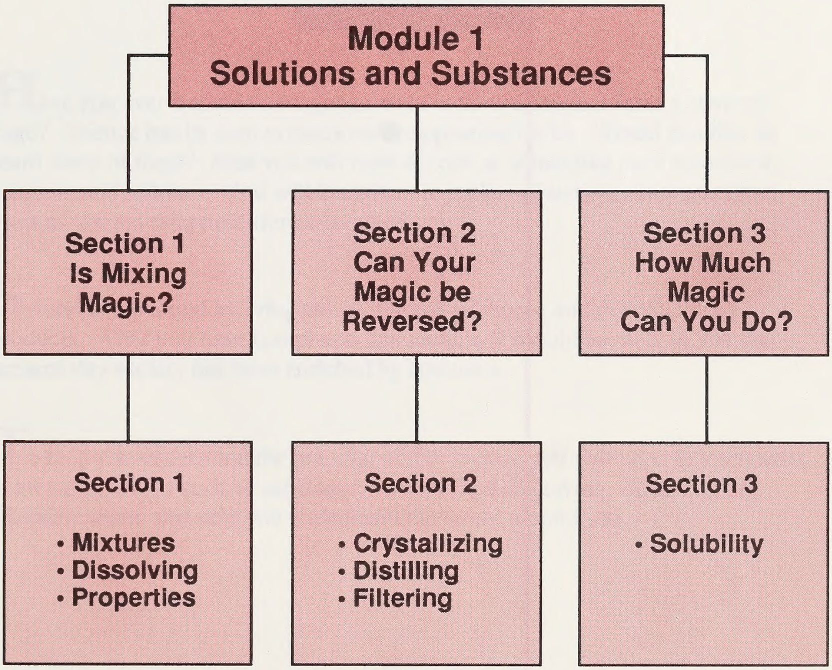
turn on your audiocassette and listen.

Contents

OVERVIEW

Can you make sugar disappear in water?
Can you make solid sugar reappear from sugar water?
Can you make solids dissolve faster?
Can you determine how much sugar will disappear in hot water?
Can you make impure water pure?
Can you remove the soil from muddy water?

The previous questions are examples of what a chemist might choose to explore. In this module you will be the student scientist investigating the amazing world of solution chemistry. You will learn that mixtures can be classified and how these mixtures can be separated.



Evaluation

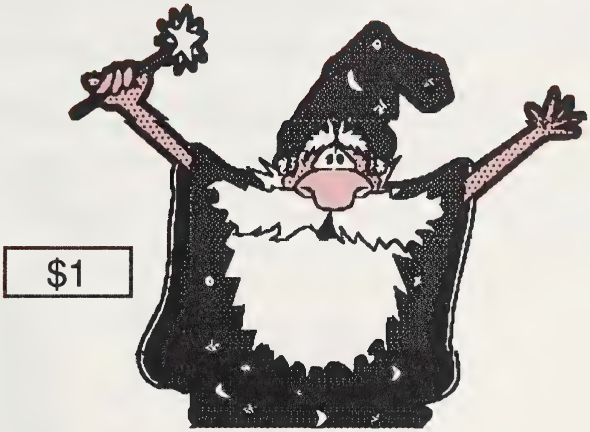
Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete three section assignments. The assignment breakdown is as follows:

Section 1 Assignment	**40%**
Section 2 Assignment	**30%**
Section 3 Assignment	**30%**
TOTAL	**100%**

Section

1

Is Mixing Magic?



Have you ever watched a magician make a dove disappear from a covered cage? Science has its own mysterious disappearing tricks. Would you like to learn some of these? First you will need to look at words like *pure substance*, *mixture*, and *solution*. You will learn how to make substances disappear from view as you investigate different mixtures.

Solutions are found in living things, natural products, and manufactured products. After you have completed this section, it should be clear to you that present-day society has been enriched by solutions.

To help you understand the material of this section you will need to learn what is meant by words such as *substance, mixture*, and *dissolving*. Knowing the scientific terms will help you understand the world around you.

Matter: something that has mass and occupies space

Activity 1: Substances and Mixtures

Have you ever looked at a structure and wondered what **matter** it contained?

Have you ever used the science inquiry model?

Did you know that your kitchen can become a science laboratory?

Have you ever wondered why some matter disappears when you put it in water? If sugar were pure, you would have a pure substance.

If you pour milk on a bowl of cereal you will create a mixture. When you add sugar, you add to the mixture. Cooking is a practical application of the chemistry of mixtures.

What kinds of matter can you think of?

Take five minutes and on a sheet of paper make a list of common products used in households. Include natural gas in your list.

Do any of the products have common characteristics?

Classifying matter is based on the similarities of matter.

1. Look back at the list you brainstormed. Using that list, answer the following questions.

   a. How many products are solids? __________

   b. How many are liquids? __________

   c. How many are gases? __________

   d. How many of your substances do you consider dangerous? __________

Pure substance: a substance that contains only one kind of matter

Mixture: a substance that is made up of more than one kind of matter

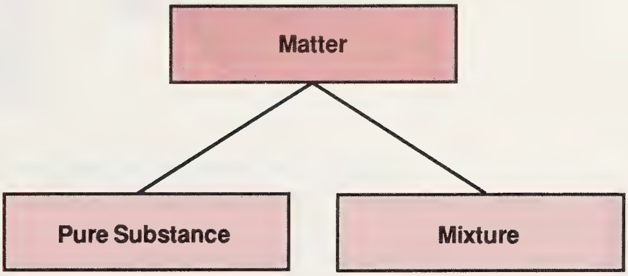
Natural: not made by people

Human-made: manufactured by people

In this activity you will begin to study the classification of matter. From your text, *Science Directions 8*, read page 2 and Looking at Mixtures on page 7.

Classifying is used to gain scientific knowledge. Matter can be classified into **pure substances** and **mixtures**. Mixtures can be **natural** or **human-made**.

There are over 100 elements known to humankind. Gold, silver, iron, mercury, and oxygen are a few of these elements that you have heard of. Most elements can combine with at least one other element to form a compound. The number of compounds possible is hard to imagine. Pure substances contain only one element or one compound. With all of those combinations you will think that pure substances are easy to find. This simply is not the case. Pure substances can rarely be found. Most matter that you know of is a mixture.



2. Explain the differences between a mixture and a pure substance.

Safety is very important for everyone in a science laboratory. To increase your safety knowledge, read your text, *Science Directions 8*, pages xii through xiv.

3. List five main safety tips you should always follow in a science laboratory.

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Check your answers with your learning facilitator.

8 Science Directions

The science inquiry model will be your guide for explorations in this module. To understand the inquiry model better, first read Activity 1-2 on page 8 of *Science Directions 8*. When you have finished reading, complete the six steps that follow.

Step One: Questioning

4. What is the problem given in Activity 1-2?

Step Two: Proposing Ideas

5. How do you think mixtures are classified?

If you made a guess, but did not explain why your guess was correct, then the answer you wrote was a prediction.

A hypothesis is more than a guess. A hypothesis includes reasons to support your guess. You cannot use feelings; you must explain using facts.

Step Three: Designing Experiments

When you design an experiment, think carefully of the materials you need. Test tubes are indicated in your text. Medicine vials, for example, will work just as well. If you only have one container, you will have to wash and dry it before you make your next mixture.

8 Science Directions

The chart in Step Five shows what mixtures you will be making. Follow the procedure in Activity 1-2 of *Science Directions 8*. You will only need the procedures numbered 1, 3, and 4. You write your own procedures; numbering or lettering the steps is a good idea.

Step Four: Gathering Data

Charts are handy and easy to make. They will help you see patterns or trends you might otherwise miss.

Now you can mix your ingredients and observe. Make and record your observations for at least seven mixtures in the chart.

Step Five: Processing Data

6. Complete the chart as you make your mixtures.

Mixture	Observations
water and vinegar	
water and cooking oil	
salt and pepper	
sugar and baking soda	
water and baking soda	
cooking oil and baking soda	
salt and water	
water and sugar	
sugar and cooking oil	

Step Six: Interpreting Data

Use the chart in Step Five to answer the questions that follow.

7. a. Name a solid substance that seemed to disappear when mixed with another substance. ______________________________

   b. What was it mixed with? ______________________________

8. a. Name a liquid substance that seemed to disappear when mixed with another substance. ______________________

   b. What was it mixed with? ______________________

9. Name two mixtures where both parts were visible after mixing.

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10. *Your mixtures were neither pure substances nor natural substances.* Explain why this statement is true.

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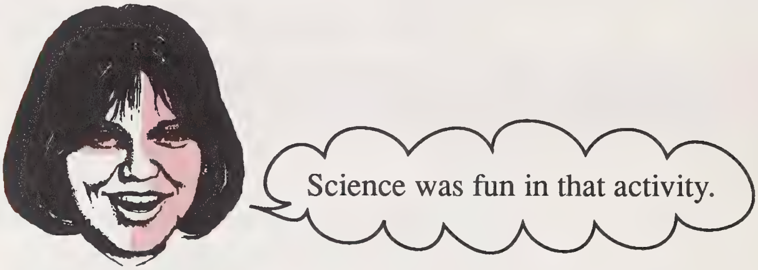
Check your answers with your learning facilitator.

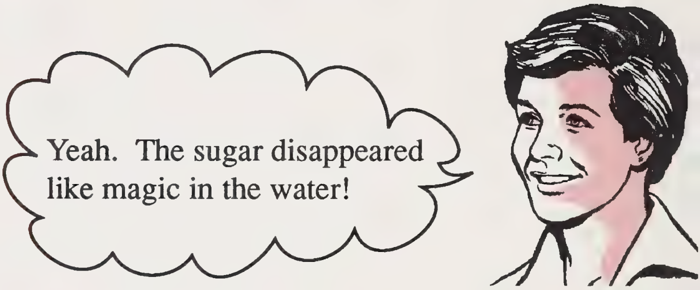
Look back at the list you made at the start of Activity 1. Think back to the similarities you found between some household products. You were starting to classify matter in your own way. Now you have learned how to classify matter into pure substances and mixtures. Both types of matter can be natural or human-made.

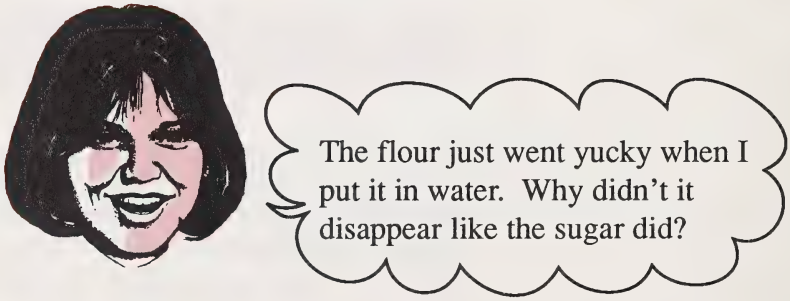
When you pick up a product, look at its label. On most labels you will find a list of ingredients. This will add to your knowledge that on earth almost all matter is a mixture.

Activity 2: Solutions

Think back to Activity 1. Did anything unusual happen?







What do you think the answer is to the question asked by the student?

Dissolving: *two substances combining so that they appear as only one substance*

Soluble: *having the ability to dissolve*

Solution: *what is formed when one substance dissolves in another*

Homogeneous mixture: *a solution in which the solute is soluble*
The solute dissolves in the solvent.

Solute: *the substance that dissolves in a solvent to make a solution*

Solvent: *the substance that dissolves a solute to form a solution*

Sugar will **dissolve** in water. That means sugar is **soluble** in water. When soluble matter dissolves, a **solution** is formed. A solution can also be called a **homogeneous mixture**.

In a solution the soluble matter is called the **solute**. The matter that dissolves the solute is called the **solvent**.

Read pages 7, 10-12, and 14 in your textbook in order to learn more about these terms.

1. What is a homogeneous mixture? Include the words *homogeneous*, *dissolve*, *solvent*, and *solution* in your answer.

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2. What is the difference between a solute and a solvent?

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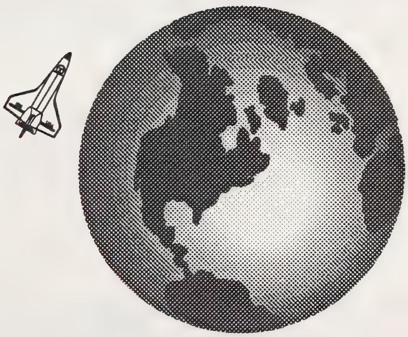
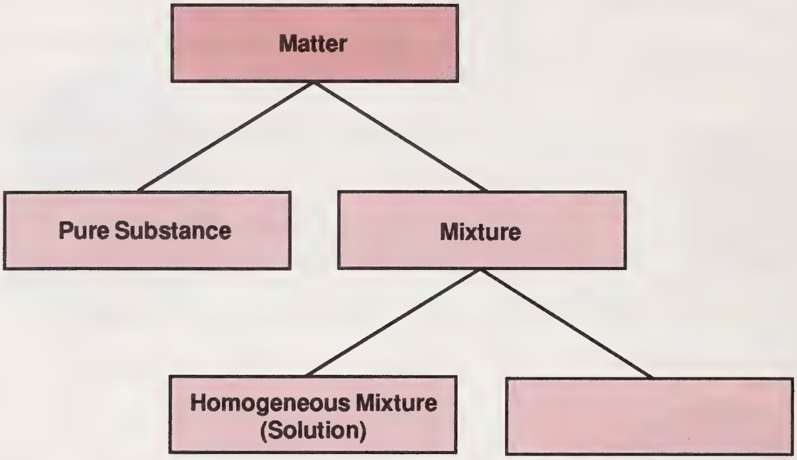
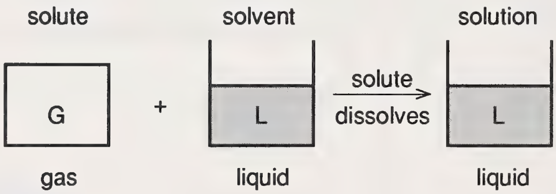


Did you know that the largest solution on earth is air? It is a mixture of gases. Solutions can be solids, liquids, or gases. The focus of this module is liquid solutions. Liquid solutions are easy to recognize. They will always be clear liquids. Have you already figured out that oceans are the largest liquid solutions?

Now you have more pieces to add to the puzzle of matter started in Activity 1. The missing pieces will be given to you soon.

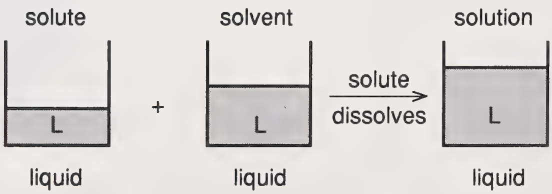


One way for a solution to form is to have a gas dissolve in a liquid.

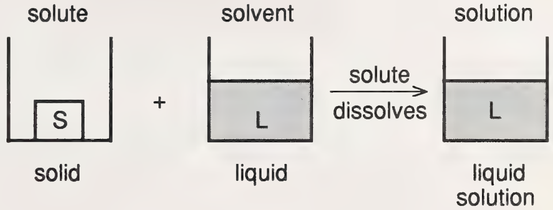


Carbonated soda and chlorinated water are familiar examples. In both cases a gas dissolves in a liquid to form a solution. Which of the two examples do you prefer to drink?

A second way for a solution to form is to have one liquid dissolved by another liquid.



When you mixed vinegar in water in the first activity you made a liquid solution using two liquids. There is a third way a liquid solution can form. A solid can dissolve in a liquid to form a solution too.



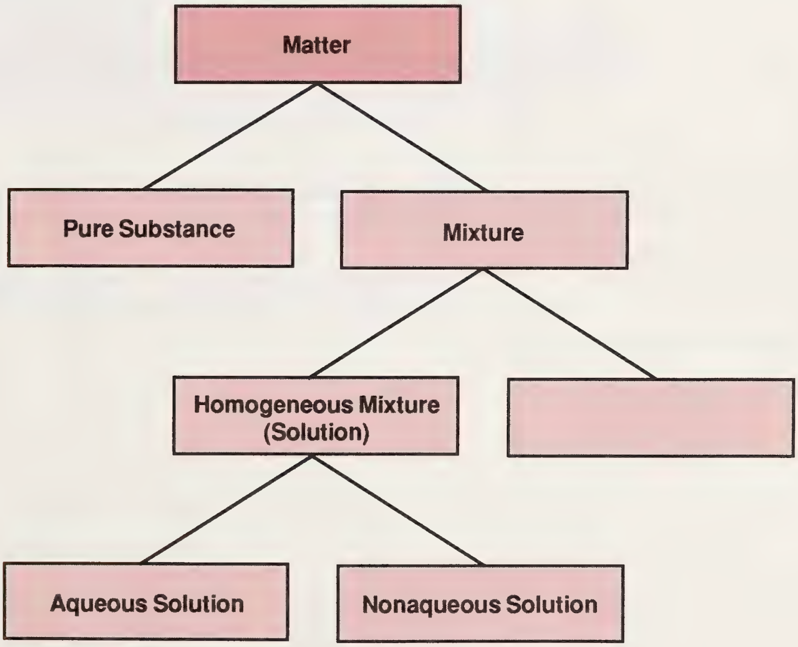
Sugar water is an example of a liquid solution formed in this manner.

Aqueous solution: a solution in which water is the solvent

Nonaqueous solution: a solution in which water is not present

There are two types of liquid solutions. An **aqueous solution** is formed when water is the solvent. If water is not the solvent then a **nonaqueous solution** is produced.

Some more pieces have been added to the puzzle of matter. Only one piece is missing. Do you know what it is?



From what you have learned, answer the following questions.

3. How do you know when a liquid solution has formed?

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4. What are the three ways a liquid solution can form?

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5. What is the difference between an aqueous solution and a nonaqueous solution?

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6. Give an example of an aqueous solution and a nonaqueous solution.

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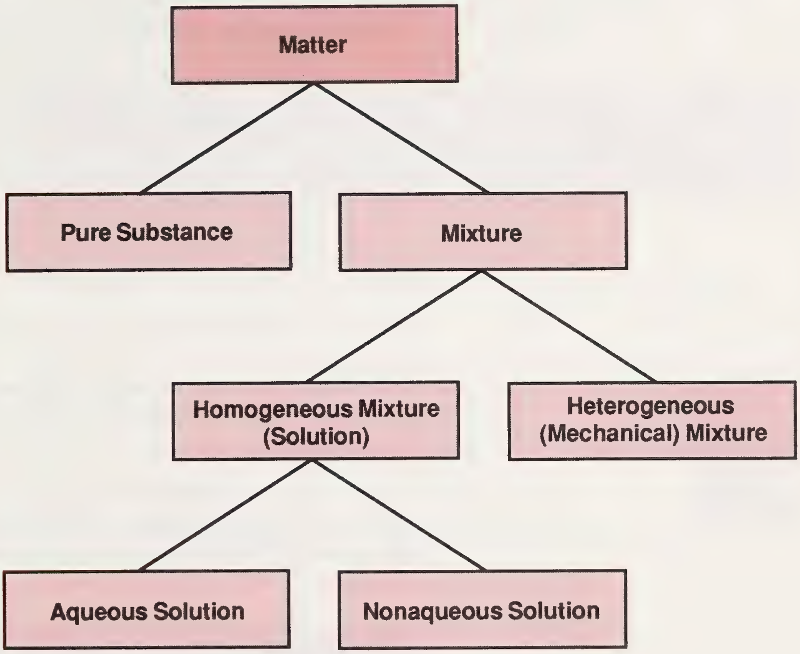
Heterogeneous mixture: *a mixture that does not form a solution*
The solute is insoluble. The solute does not dissolve in the solvent.

Insoluble: *unable to dissolve*

A **heterogeneous mixture** is formed when dissolving does not occur during mixing. Heterogeneous mixtures are sometimes called mechanical mixtures.

Flour will not dissolve in water. That means flour is **insoluble** in water. Flour and water combine to form a heterogeneous mixture.

Now you can have the last piece of the puzzle to complete the picture of the kinds of matter.



7. Explain the difference between homogeneous and heterogeneous mixtures. Include the alternate name for each.

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8
Science Directions

Your textbook has examples of both natural and human-made solutions. Check Tables 1-2, and 1-4 for their examples. The Did You Know columns on pages 11, 27, and 28 have examples too.

8. Classify some of the solutions you have just found as either natural or human-made. Complete the chart so that you have six examples of each kind of solution.

Natural Solutions	Human-made Solutions
tears clear air	clear apple juice

Check your answers with your learning facilitator.

9. Use your observations from Step Five in Activity 1. Decide if the solute was soluble or insoluble. Classify each mixture as being either homogeneous (a solution) or heterogeneous. You may leave the boxes blank for the two mixtures not completed in Activity 1.

Mixture	Soluble or Insoluble	Homogeneous or Heterogeneous Mixture
water and vinegar		
water and cooking oil		
salt and pepper		
sugar and baking soda		
water and baking soda		
cooking oil and baking soda		
salt and water		
water and sugar		
sugar and cooking oil		

10. Which mixtures were aqueous solutions?

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11. None of the mixtures were nonaqueous solutions.
Give an example of a nonaqueous solution.

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12. For each of the homogeneous mixtures identified, name the solute and solvent. Put a cross in the Solute and Solvent boxes if the mixture is a heterogeneous mixture. Leave the boxes blank for the two mixtures you did not make.

Mixture	Solute	Solvent
water and vinegar		
water and cooking oil		
salt and pepper		
sugar and baking soda		
water and baking soda		
cooking oil and baking soda		
salt and water		
water and sugar		
sugar and cooking oil		

Check your answers with your learning facilitator.

Think back to the conversation that the students were having concerning the mixing of sugar and flour in water.

The next activity deals with how quickly a solution can form. You can prepare for the next activity by trying this experiment. Take a glass of water and a sugar cube. Put the sugar cube in the water and time how long it takes for the sugar cube to dissolve. Using a similar sugar cube and the same amount of water as you used on your first trial, try to decrease the dissolving time.

Hint: There are three different ways to shorten the dissolving time.

Activity 3: Dissolving Factors

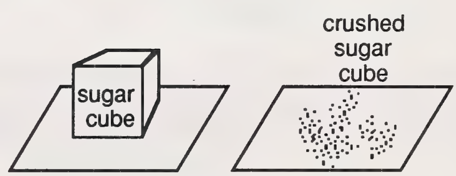
There are various cold drinks you pour from a package or spoon from a can. Most of these you mix with water. How many of these products can you think of? Take about three minutes and think. What is your favourite kind? What do you do when you mix it?

Mechanical movement: stirring or shaking

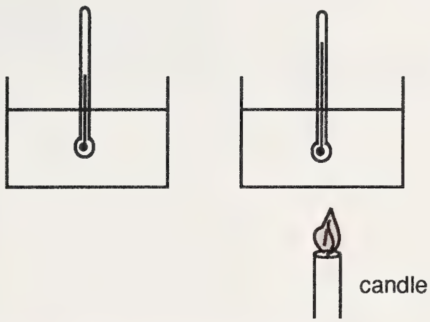
There are three factors that determine dissolving rate. These factors are particle size, temperature, and **mechanical movement**. You may have known enough about these factors already if you were very successful in the race to beat the sugar cube's dissolving time at the end of Activity 2.

Take out two sugar cubes. Take one sugar cube in your hand. Look at its outside surfaces. When water starts to dissolve a sugar cube, it must start from the outside. The inside of the cube cannot be reached until the outside is dissolved.

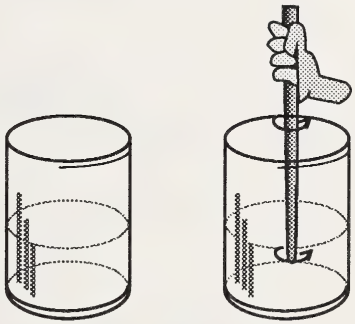
Take the second sugar cube. Crush it. Look at the cube's remains. Imagine these remains being placed in water. When the water starts to dissolve the crushed cube, it starts on the inside of the cube as well as the outside surface. The larger the particle of solute is, the slower it will dissolve.



If you increase the temperature of your solvent, the solute will dissolve faster. The hotter the solvent, the faster the particles of solvent move. Faster motion of particles means more collisions with the solute's surface. The solvent has to hit the solute for dissolving to occur.



Mechanical movement speeds up dissolving too. Stirring and shaking also increases the number of collisions that the solvent particles make with those of the solute.



If you want to really speed up dissolving, then use all three dissolving rate factors to your advantage. Increase the temperature of the solvent, reduce the size of the solute, and stir or shake the solution after you add the solute.

You know that dissolving rate can be increased. The information presented is probably not very new. Now it is time to prove that one of these factors is true. In science, the best method for studying the effect of one variable on another is the inquiry method.

Step One: Questioning

1. Think about the situation. There are three possible problems that could be investigated by experiment. Each of these relates to dissolving. One of these is given to you. What are the other two?

   a. What effect does temperature have on the dissolving rate of sugar?

   b. ____

   ____

   c. ____

   ____

Step Two: Proposing Ideas

2. Write your hypotheses for the three possible investigations.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

Step Three: Designing Experiments

You are going to continue the science inquiry method with only the first problem given.

3. Write the procedure you are going to follow to test your hypothesis.

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Step Four: Gathering Data

Design a chart to record your observations. Draw it in Step Five. Try out your procedures. Record your results on your chart.

Step Five: Processing Data

4. Draw the chart you designed. As you follow your procedure, enter your results in the chart.

Step Six: Interpreting Data

5. What effect does temperature have on the dissolving rate of sugar?

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6. Was your hypothesis correct? Explain.

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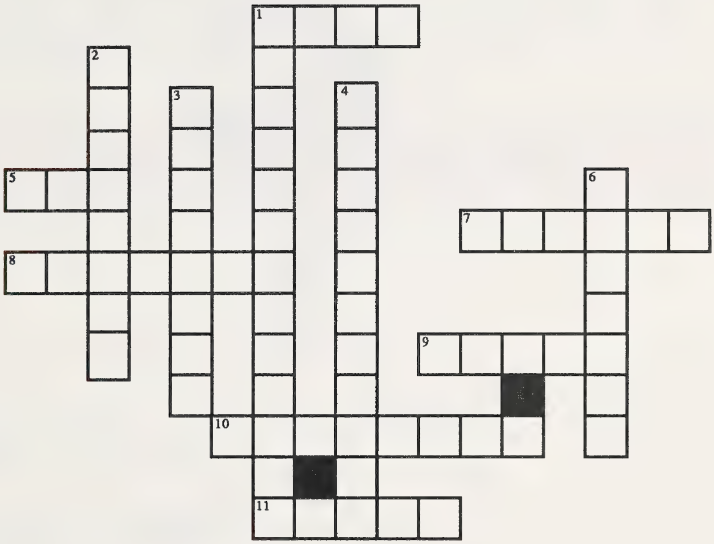
7. There are three dissolving-rate factors. State what these three factors are. Explain how each factor influences the dissolving rate of a solute.

Check your answers with your learning facilitator.

8. The puzzle will give you an opportunity to review many of the new terms you have learned in this module. Complete the puzzle.



Across Clues

1. change temperature upward
5. solid water
7. intelligent creatures
8. changing liquid to gas
9. something to swim in
10. homogeneous mixture
11. water gas

Down Clues

1. type of mixture
2. changing liquid to a solid
3. relating to material things
4. increases during heating
6. not manufactured

Check your answers by turning to the Appendix, Section 1: Activity 3.

You are a dissolving rate expert. Use your skills positively like the following students did.

9. People drink a variety of liquid solutions. Over the next two days keep a list of the liquid solutions you see people drinking. Fifteen or twenty minutes will be all the time you need to do this exercise. There is no need to search very hard. Liquid solutions are very common. Along with your list, keep track of the colours and any other unusual characteristics that the liquid solutions have.

Share your answers with your learning facilitator.

Activity 4: Solution Properties

Have you ever gone ice fishing or skated on a frozen pond?

Have you ever gone swimming in a beautiful lake or pool?

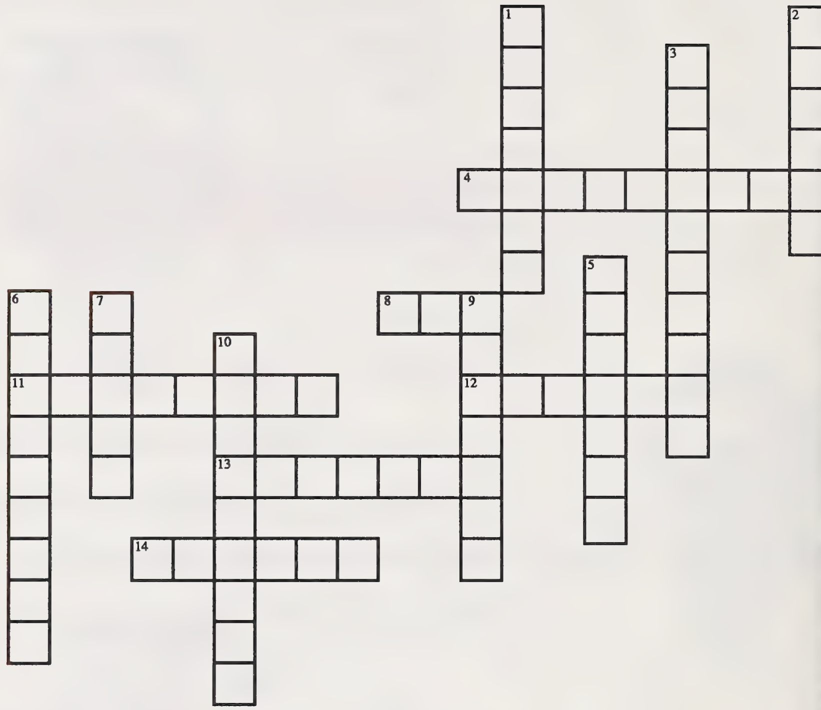
Have you ever witnessed a geyser erupting?

Have you ever seen food colouring spread through a clear glass?

What do ice, drinking water, and steam have in common? How are they different?

It is helpful to review some of the terms you will use in this activity.

1. Complete the following puzzle.



Across Clues

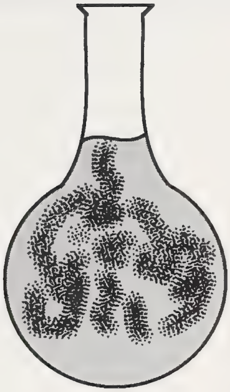
4. made of matter
8. gives the fizz to pop
11. mixture formed by dissolving
12. not solid or gas
13. can dissolve
14. disappears in solution

Down Clues

1. two or more substances
2. has mass and volume
3. manufactured
5. formed without our help
6. will not dissolve
7. ice is this
9. dissolves
10. what happens to a solute to make it disapper

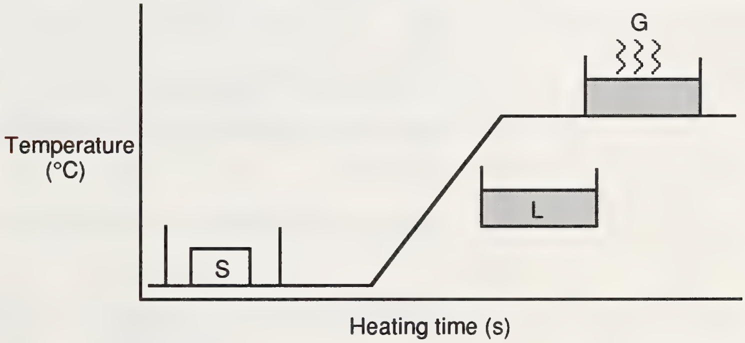
Check your answers by turning to the Appendix, Section 1: Activity 4.

When you add food colouring to water, the mixture is a clear liquid. Do you think that food colouring and water is a solution or a heterogeneous mixture?



Solutions are clear liquids. Solutions can be any colour. Sometimes when you add a solute the original colour of the solvent changes.

Effect of Heat on Temperature



Study the preceding graph. Do you know what *S*, *L*, and *G* represent?

2. All types of matter can be a solid, liquid, or gas. Water has three different names depending on whether it is a solid, liquid, or gas. Write these names and indicate whether the name refers to solid, liquid, or gaseous water.

3. An increase in temperature can change solids to liquids. What other changes can a change in temperature make? Before you answer this question, ask yourself, “Does temperature only increase?”

There are two flat areas on the previous graph. What do you think these flat spots represent? Assume the graph is for water.

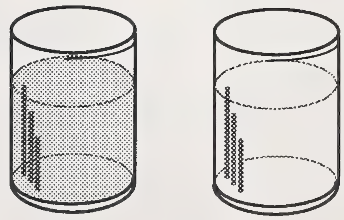
Freezing point: the temperature at which a liquid turns to a solid

Boiling point: temperature at which a liquid turns to a gas

The ice cube is resting on the **freezing point**. When liquid water reaches the freezing point it starts to turn to ice. The steaming pan is sitting on the **boiling point**. When water reaches the boiling point it starts turning to steam. During a change from ice to water and water to steam, the temperature stays constant until the change is complete. This explains the flat spots.

When a solute is added to water, the boiling point of the solution may be raised or lowered.

The same is true regarding the freezing point of the solution.



Physical appearance: what something looks like
For example, size, shape, and colour are familiar examples of physical appearance.

When you make a glass of iced tea or a cup of instant coffee, the **physical appearance** of the water changes.

Prepare at least three different aqueous solutions. Each solution must have a different colour.

4. Write a paragraph based on your observations. For each solute used, describe the physical appearance of the solution containing that solute. If you are working at home, consider making solutions that are safe to drink. If you do so, you will have something to enjoy while you write your paragraph.

5. At sea level the boiling point of water is 100°C.
What can happen to that boiling point if a solute is added?

8
Science Directions

Page 46 of *Science Directions 8*, has information on the use of salt on roads.

6. Why is salt used on roads in the winter time?

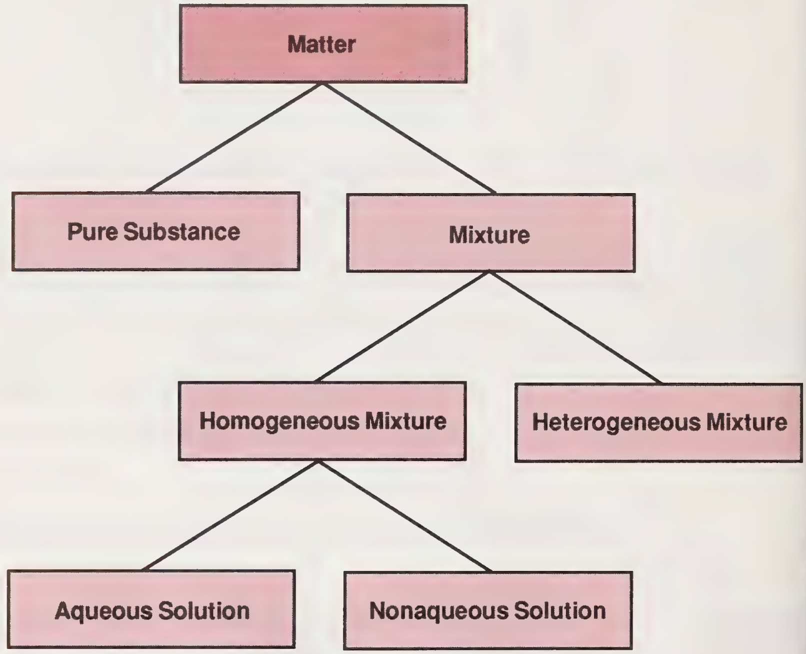
Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

To help you master the concept of mixtures, study the following material thoroughly and complete the questions that follow it.



- Matter has mass and occupies space.
- A solution is formed when a solute dissolves in a solvent.
- Dissolving rate is affected by particle size, temperature, and mechanical mixing (stirring).
- Solutes can change a solution's physical appearance and its boiling and freezing points.

Have you noticed the number of concepts that occur in pairs?

- Matter can be a (pure) substance or a mixture.
- If a substance dissolves, it is soluble. If it does not dissolve, it is insoluble.
- Mixtures can be homogeneous (soluble solid) or heterogeneous (insoluble solid).
- Homogeneous mixtures are called solutions.
- Solutions are aqueous (water as the solvent) or nonaqueous (no water present).
- Solutions can be natural or human-made (manufactured).

1. Complete the following table.

Term	Meaning and Example
soluble solution	
aqueous solution	
insoluble solute	
nonaqueous solution	

Term	Meaning and Example
heterogeneous mixture	
natural nonaqueous solution	
human-made aqueous solution	

Check your answers with your learning facilitator.

Enrichment

You have learned that solutions can be made naturally or by humans. Apply what you have learned to answer the following question.

1. Imagine that it is spring time. You live on a farm in northern Alberta. Most of your community's business depends on tourism. You have a huge pond on your property. Experts have told you that your livestock will never be able to drink from the pond. Financially, you are almost broke. If you do not make money soon, you are going to lose your farm. Using what you have learned about solutions and their physical properties, create a use for the pond that will attract tourists.

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2. Your project might affect others. What environmental considerations should you make before proceeding?

Discuss your answers with your learning facilitator.

Conclusion

In this section you have learned some of the mysteries of why substances disappear. You now have a better appreciation for the solutions in your environment. The most important concepts you have learned are these:

- Matter is anything that has mass and volume.
- Pure substances are made from only one kind of matter.
- Mixtures are made of two or more kinds of matter.
- Solutions are special mixtures called homogeneous mixtures. In solutions, one substance (solute) dissolves in another (solvent). When solutes are insoluble, heterogeneous mixtures result.
- Aqueous solutions have water as a solvent. The solvent for nonaqueous solutions is not water.
- Dissolving rates can be increased by increasing the temperature, reducing particle size, and stirring.
- Adding more solute changes solution properties.

Assignment Booklet

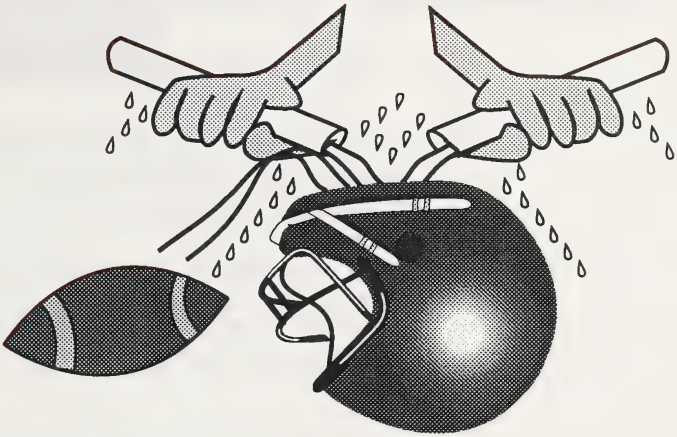
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

2

Can Your Magic Be Reversed?



To what extent is solution chemistry a practical science? In this section you will be given a chance to find some answers to this question.

To understand the idea of practical science you will learn the meanings of concepts such as filtration, distillation, and crystallization.

In this section you will be given the opportunity to develop your problem-solving skills by understanding problems and developing, carrying out, and evaluating your plans.

This section is divided into two parts. In the first part you will work with separating heterogeneous mixtures. Often it is necessary to separate heterogeneous mixtures to get homogeneous solutions. In the second part you will examine the separation of homogeneous solutions. This will provide you with examples of how solution chemistry plays an important part in your life.

Activity 1: Filtration

In a clear container mix 500 mL of water and two teaspoons of dry sand. Stir the mixture. Watch and note what happens over three minutes. The problem you have now is to separate the mixture. Can you think of two or three ways to separate the sand from the water. Try the method you think will work best. Were you successful? How could you improve your design? How could you use your separation method to help others? Save the water you collected in a sealed container. You will need it later in this activity. Place the wet sand in an open plastic container. Put this container in a warm, dry place. You will need it for Activity 2.

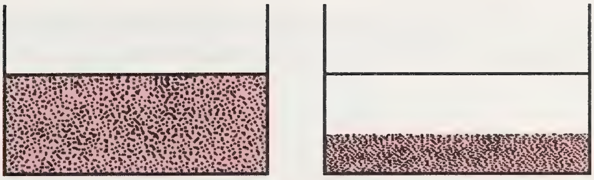
Think back to the observations you made of your mixture.

What happened to the sand particles?

Settling is the simplest method to separate water and sand. The last two pictures illustrate settling. After stirring, the sand settles to the bottom of the still water. The water is poured off carefully, leaving the wet sand. The sand is then allowed to dry.

At the beginning of the activity you separated sand and water. If you did not use settling, repeat the steps using the settling method and save the containers for the end of this activity.

For more information on separation, read pages 18 to 24 in *Science Directions 8*. (Remember that mechanical mixture is another name for heterogeneous mixture.)



1. What separation procedure is shown?

2. Explain how to separate using this method.

3. What separation procedure is shown?

4. Explain how to separate using this method.

Check your answers with your learning facilitator.

In Section 1 you learned the science inquiry steps. Now you will apply the problem-solving steps used in Grade 7 Science when you studied structure and design.

The settling method works well for some mixtures. When you tried this method did the water you poured off contain any sand?

Step One: Understanding the Problem

The purpose is to try to find a method to get clean water from sandy water. You must separate the sand and water by filtering.
To be successful your water sample must be cleaner than the sample you collected by settling.

Step Two: Developing a Plan

5. Great plans seldom come without thinking. Use one of the two filtering methods you have already learned, or design your own. Explain your plan. You may draw a model if that will make it easier.

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Step Three: Carrying Out the Plan

Test your design. Make changes to your equipment if needed.

Step Four: Evaluating the Plan

6. Did your design work better than the settling process? Explain.

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Evaluate your planning process. How long did you spend planning? Did you look at more than one alternative? Can you think of a better method now?

Try your apparatus with a coloured water solution.

Filtration will not separate homogeneous mixtures!

7. Why does the dye go through your filter with the water?

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Check your answers with your learning facilitator.

Show another person how your filtration apparatus works. Keep your eyes open for other filters. You will be amazed at how many types there are.

Activity 2: Distillation

Have you ever made sand castles? How big was yours? Did you use wet sand? How long does it take wet sand to dry?

Look at your container of wet sand from Activity 1. Is the sand dry? How does sand dry?

Evaporation: the process in which liquid changes to a gas

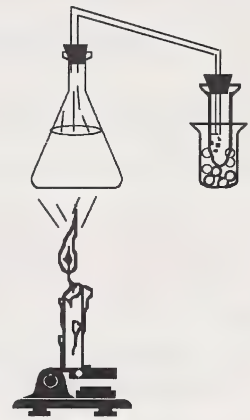
Evaporation is powerful and unrelenting. The warmer and drier the environment, the faster the rate of evaporation.

Evaporation is an effective way to separate the solute from the solvent in homogeneous mixtures. The only problem is that by the nature of the process you lose the solvent. Is there a way to collect the solvent when it evaporates?

8 Science Directions

Distillation: when a liquid is evaporated and collected

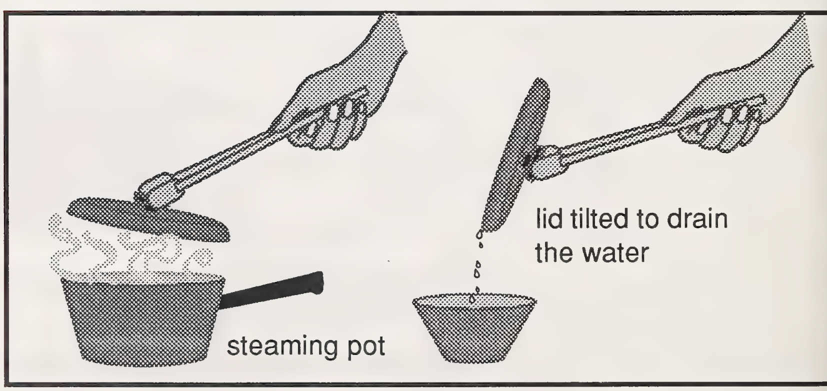
Read pages 29, 32, and 33 in *Science Directions 8*. You will find two examples of a **distillation** apparatus. Study the diagrams and the information given. In your study of distillation you will use only aqueous solutions. Your equipment will be simple. The petroleum industry uses more complex equipment since more complex mixtures are being separated.



In the previous diagram the aqueous solution in the flask is heated until it boils gently. The vapour rises into the glass tube. When the vapour reaches the test tube it is cooled. The vapour condenses (turns back to a liquid). The liquid collected is called the **distillate**. The **residue** is the matter left when the distillate is removed.

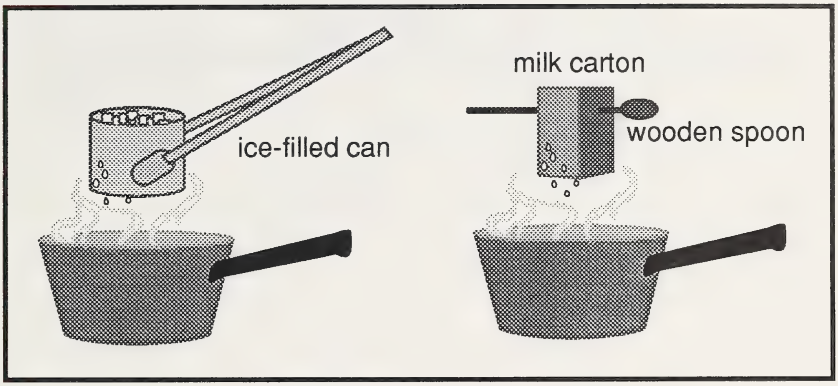
Distillate: the liquid collected during distillation

Residue: the matter remaining following distillation or filtration



What happens when you lift a lid off a pot of boiling water? Is the inside of the lid wet?

You can use this knowledge to make your own distillation apparatus. A lid held over a boiling solution will collect some of the distillate. For added safety, barbecue tongs can be used to hold the lid.



Instead of a pot lid a container such as a milk carton or can may be filled with ice and held safely over the steaming pot.

1. Explain how distillation works.

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Step One: Understanding the Problem

You could not filter coloured water in Activity 1. Now your purpose is to separate a coloured salt solution by distillation. You may use any colour of food colouring that is approved by your learning facilitator. You must be able to prove that your method does separate the dye from the water. You must recover at least part of the distillate. For safety reasons, be sure that your method is approved by your facilitator.

Step Two: Developing a Plan

Place 5 mL of your coloured salt water in an open plastic container. This is to be used to prove that your distiller works. At the end of the activity, leave the sample in a warm, dry place to evaporate. You will need it for Activity 3.

2. Think over your alternatives. Draw a picture of the design you decide to use for distillation.

3. Describe the steps you plan to follow.

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Discuss your answers with your learning facilitator.

Step Three: Carrying Out the Plan

4. Test your design for safety before you attempt to distill your solution. Report any changes that you have to make.

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Complete your procedure. Stop distilling before your pot boils dry.

Step Four: Evaluating the Plan

5. Evaluate your design and planning process. Be sure to give proof that your design worked.

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6. List three examples of how evaporation or distillation is used in nature, or by humans, to separate solutes from solutions.

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Check your answers with your learning facilitator.

Did you know that most substances are made of molecules? Did you know that molecules are made up of even smaller particles called atoms? Did you know that when a solution forms, the solute particles break up until they are molecular-sized? Did you know that solute particles are so small that they travel through invisible filter holes?

Activity 3: Crystallization

As I peered inside the open attic door in the old haunted house, a wondrous light emanated from the room. The room was filled with diamonds, rubies, and emeralds.

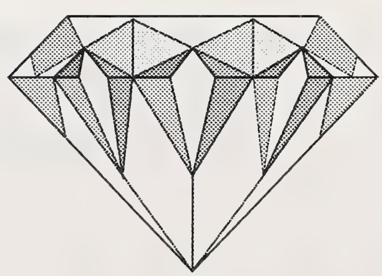
1. Finish this story.

Share your answers with your learning facilitator.

What are the names of other gem stones that you know?

Crystals: solids with distinct shapes and flat surfaces

What do almost all gems have in common? Did you know that most gems are **crystals**? Do you know how to make your own crystals?



Crystallization: a process where a solute comes together in a predictable pattern when the solvent evaporates

Crystallization is a third method of recovering solutes from solutions. Do you remember what the other methods were called?

8
Science Directions

One crystallization method is to leave the solution in a container to evaporate. The solvent can only hold so much solute. As evaporation continues, solute begins to come out of the solution. If conditions are favourable, crystals form. A second method will be discussed in Section 3.

For additional information on crystallization, read pages 27 and 28 in your text.

2. How can evaporation cause crystals to grow? Include the name of the process in your answer.

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3. Why does water from various places often taste different?

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4. How does a kidney stone form?

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Study the coloured salt water sample collected in Activity 2. When all of the water has evaporated, study the remains in the container. A hand lens will make this easier.

5. Report your findings.

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Try the same procedure with different solutions. Sugar water and lemon juice are two you could try. Compare these to your salt crystals.

Show your crystals to another person and/or to your facilitator. Explain how crystallization of solutes in solutions work. Keep it simple if you are talking to someone younger.

Share your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Study the summary for separation methods.

- Some heterogeneous mixtures can be separated by settling and pouring off, or by filtration.
- Evaporation may be useful for separating aqueous solutions.

- Large insoluble particles settle to the bottom of a mixture. The liquid can be poured off to complete separation.
- Filters have tiny holes in them. Filtration will work when the holes are too small to let one substance of the mixture through.
- Filtration does not work with homogeneous mixtures. The holes are not small enough to trap the solute.
- Evaporation and distillation will separate aqueous solutions.
- In separation by evaporation the liquid turns into a gas. The solute is all that is left in the container.
- Some aqueous solutions form crystals because of evaporation.
- Distillation and evaporation methods are very similar. However, in distillation the evaporated liquid is recovered.

1. Complete the chart.

Separation Method	Explanation of How This Method Works
Settling	Heavy particles fall to the bottom of the container. Then the liquid is poured off.
Filtration	
Evaporation	
Distillation	
Crystallization	

2. Give an example of a mixture that you could separate using each of the methods indicated.

   a. Crystallization

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   b. Filtration

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   c. Settling

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   ____

   d. Distillation

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   ____

   e. Evaporation

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Check your answers with your learning facilitator.

Enrichment

You are the local town's environmental consultant. The town's drinking water has suddenly turned muddy, and you need to present to town council possible alternatives to remedy the problem. You were not asked to investigate the cost of each alternative. That is the responsibility of the engineering department. Town council has requested that you present at least three alternatives for review.

For each alternative, give the name of the separation process and how it could solve the muddy drinking water dilemma.

Share your answers with your learning facilitator.

Conclusion

Solution chemistry brought about great change in the world. The secrets of solution separation spread to areas like biology, medicine, and manufacturing. Solution separation became an important part of people's lives. It is still important to you today.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

How Much Magic Can You Do?

What is the solubility of salt in water? Is solubility affected by temperature? In this section you will be given an opportunity to answer these questions.

To understand what solute solubility is you will need to learn the meanings of concepts such as concentration and saturation point.

In this section you will be using your science inquiry skills to investigate solute solubility.

This section is divided into two parts. In the first part, you will learn what solubility is. In the second part, you will compare the solubility of two different solutes.

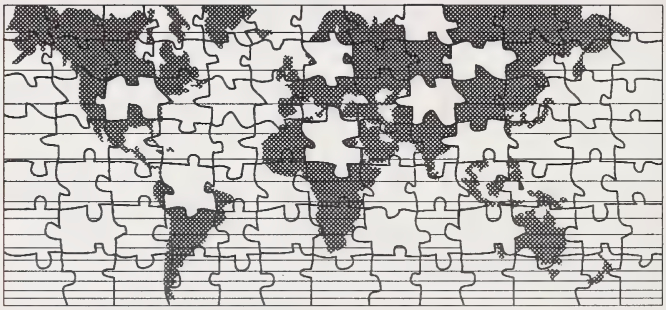
Activity 1: Science Inquiry

Imagine having an elastic band around your wrist and held with your other hand. Stretch it a little. Now stretch it even more. Let go of the end. What happened?

In some instances nature is like an elastic. If you pull on an elastic, the elastic pulls back. If you change nature, nature strikes back.

Variables: the factors that can change in an experiment

Human changes causing natural changes is the basis of the science inquiry model that you learned in Section 1. Changes in science inquiry are called **variables**.



The science inquiry model can be likened to a jigsaw puzzle. The puzzle, in this case, is of nature. Each inquiry experiment can be likened to a single puzzle piece. Scientists around the world are working on this super puzzle. It is still far from being complete. Each experimental breakthrough reduces the number of puzzle pieces left for future scientists to place.

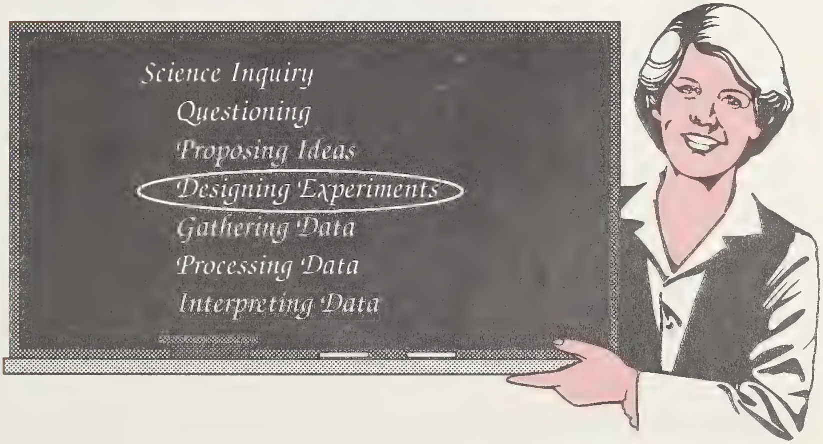
Manipulated variable: the factor that you, the scientist, change

What you, the scientist, change is called the **manipulated variable**. When the student pictured in the first part of this activity stretched the elastic band, the student tried to manipulate nature. Do you change behaviour when you feel manipulated? Nature often does.

Responding variable: nature's response to changes that a scientist makes

The difference your change causes in nature is called the **responding variable**. What was nature's response when the young girl let go of the stretched elastic? Nature's response is not always so painful.

As a scientist, you want to study nature's response to your manipulation. You must prove that nature's response is due to your manipulation. To do this you must change only one factor (manipulated variable). This difference must cause only one change (responding variable). By changing only one factor you prove the response you observe was caused by your manipulation. Manipulating one factor is crucial to the inquiry process.



Controlled variables: factors that could change but are not allowed to change during a science inquiry experiment

In the inquiry process you must prevent any other factors from affecting your work. The name given to these factors is **controlled variables**.

In the science inquiry process you will manipulate one variable (manipulated variable) and study nature's reaction (responding variable). You must not allow any other factor (controlled variable) to affect your results. To do this you make two trials. In the second trial the manipulated variable is changed. Now you are able to make a comparison.

1. What are manipulated, responding, and controlled variables?

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Scientists using the inquiry model usually make at least two trials. In the first trial, no manipulation occurs. Nature's response is studied. In the second trial, one manipulation is made and nature's response is observed. The second trial gives scientists a comparison between nature's response and a manipulated response.

Sometimes both trials are done at the same time. Think back to Section 1, Activity 1. In that activity you studied the effect temperature has on the dissolving rate of a sugar cube. You may have used two cups, each at a different temperature, and dropped both sugar cubes in at the same time. If you did, then you completed both trials at the same time.

2. In an inquiry experiment a scientist makes at least two trials. Why?

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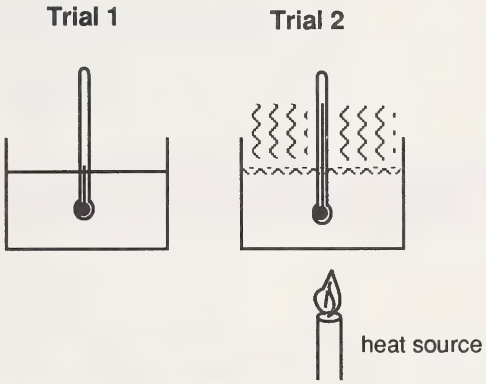
In inquiry, the problem you write must include the manipulated variable and the responding variable. One way of doing this is to memorize the statement:

What effect does _______________ have on _______________ ?

The first blank is for what you plan to change (manipulated variable); the second is for nature's reaction (responding variable).



3. What is the problem shown in the previous graphic?
   Use the "What effect does ____________ have on ___________ ?" format.

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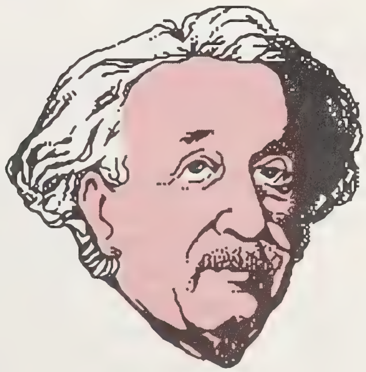


It is your turn again to be a scientist. You are going to use the science inquiry method to learn more about solutions.

In Section 1 you discovered that salt and sugar were soluble in water. Your task is to determine the maximum amount of each solute that will dissolve in an equal volume of water. Make sure the water is the same temperature for both trials. Record this temperature on your chart in Step Five.

If you do not have a thermometer, use water at room temperature. This water will have the temperature shown on the thermostat or close to it.

Using the task description, identify the manipulated and responding variables for the experiment. Include these variables in the problem you write in Step One.

Step One: Questioning

4. What is the problem?

Step Two: Proposing Ideas

5. Write a prediction that answers the problem.

Step Three: Designing Experiments

6. Write down an appropriate procedure to test your prediction. You will have to carefully measure the amount of solute you add. A tablespoon should be used to measure the solute and 100 mL of water should be used for each of the solutions.

Draw a chart to record your data in Step Five.

Complete your experiment.

Check your answers with your learning facilitator.

Step Four: Gathering Data

In your chart in Step Five, record the amount of each solute that dissolves in water.

Step Five: Processing Data

7. Show your chart with your recordings entered.

Step Six: Interpreting Data

8. Explain what your results demonstrated. Make sure to indicate whether your prediction was correct.

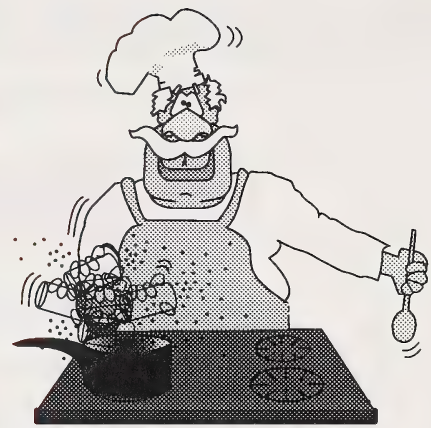
Discuss your answers with your learning facilitator.

Think back to the student stretching the elastic at the beginning of this activity. Did you know what would happen before the picture showed you? If you did, then you made a prediction that was later verified.

If your prediction was correct in the last experiment you may begin to think that this experiment was not needed. You may think personal experience has given you the answer. Personal experience gives you the insight to make reasonable predictions. To prove yourself right, complete the six steps of science inquiry.

Keep your eyes open for cause and effect. When one event occurs it is frequently followed by another. Watch for these events and report some to your facilitator. Learn to use science inquiry skills to test your understanding of what factors influence certain events.

Activity 2: Solubility

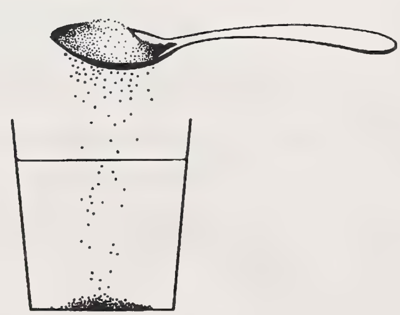


Why do chefs add more salt to their soup? Could it be that salty is not salty enough? When is a little salt more than enough?

When an elastic stretches, does it always snap back? Does an elastic stay whole, or can it break apart?

Have you ever seen someone run so hard and so fast that they ended up collapsing because their leg muscles would not work anymore?

Have you ever eaten so many vegetables that you could not eat anymore? What other examples can you think of where limits were reached?



Solubility: the measure of the maximum amount of solute that will dissolve in a solvent at a given temperature

Concentration: the measure of the amount of solute that is in a given volume of solvent

Saturation point: the point when no further solute can dissolve in a solution

What about solutions? Can they reach limits too? Are solvents like your appetite for one kind of food? Could it be that when solutions are full of one solute, no more can dissolve?

Dissolving has limits. At any given temperature there is only so much solute that can dissolve. This limit is called **solubility**.

To measure solubility you need to understand what **concentration** means. In solution chemistry, concentration is a measure of the amount of solute present in a volume of solvent. In this module you may measure concentration by recording the number of tablespoons of solute that you add to 100 mL of water. However, concentration can also be given in grams of solute per 100 mL of water.

A solution reaches its **saturation point** when it cannot dissolve any more solute. When you measure solubility you will measure the concentration of the solute when it reaches the saturation point in the solution.

1. Explain the meanings of concentration, saturation point, and solubility.

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2. How are you going to measure concentration in this module?

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3. Explain how solubility, concentration, and saturation point relate to the experiment you did in the last activity.

Check your answers with your learning facilitator.

Dissolving rate and solubility both involve dissolving. When you studied dissolving rate in Section 1, you discovered that temperature, particle size, and mechanical movement affect the speed at which dissolving occurs. Solubility refers to the maximum amount of solute that can dissolve. An increase in solvent temperature will increase the solubility of most solutes.

4. What are the similarities and differences between dissolving rate and solubility?

Hot solutions usually hold more solute than cool ones. Thus, cooling will force some of the solute out of most hot solutions. When cooled under the right conditions, some saturated solutions produce crystals. Activity 1-9, found on page 26 of *Science Directions 8*, explains in more detail how this is done.

8 Science Directions

5. How can you use your knowledge of solubility to grow your own crystals?

To compare the solubility of different solutes at different temperatures, you must study at least two different charts. This could be frustrating. You may miss trends that are easily seen by graphing. Your text outlines the basic rules of graphing on page 340. Pages 338 and 339 of the text have sample graphs.

8 Science Directions

Use the points which follow to better understand the rules for graphing.

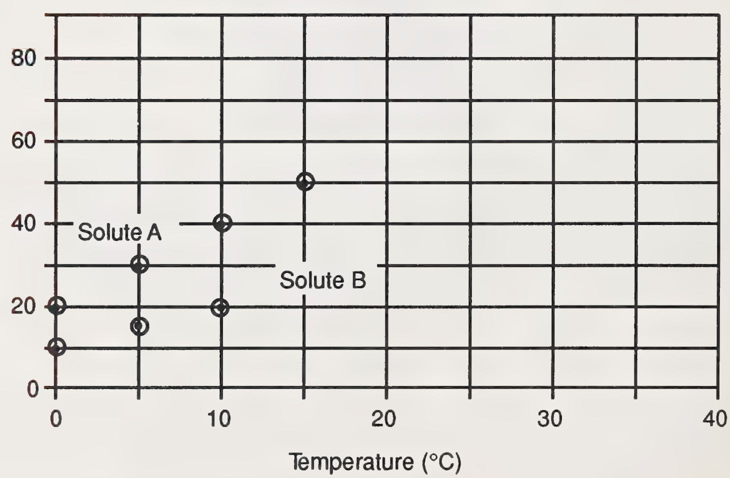
- Put a title on your graph.
- Use the horizontal axis for the manipulated variable and the vertical axis for the responding variable.
- Choose scales so that your graph covers most of the space you are to use.
- Label each axis with the name of the appropriate variable and put the units in brackets after the name.
- Circle the plotted points and connect these points with a straight line or smooth curve.

6. Use your graphing knowledge to complete the graph that follows.

   a. Determine and write in the label for the vertical axis.

   b. Using the charts that follow, plot the remaining points for the two solubility curves. Draw a straight line or smooth curve to complete the solubility curves. Use a different colour for each solute.

Temperature Effects on Solubility in Water



Temperature (°C)	Solubility of Solute A (g/100 mL)
20	60
25	70
30	80

Temperature (°C)	Solubility of Solute B (g/100 mL)
15	40
20	35
25	20

Check your answers with your learning facilitator.

Complete the following inquiry experiment.

Step One: Questioning

What effect does temperature have on the solubility of a solute?

Step Two: Proposing Ideas

7. Write a hypothesis that answers the problem.

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Step Three: Designing Experiments

a. Pour 100 mL of cold water into a clear glass.

b. Record the temperature of the water. Measure the solubility (tablespoons/100 mL of water) of salt in the water at that temperature. Record your results.

c. Repeat a. and b. using warm water.

d. Repeat a. and b. using hot water (from a kettle).

e. Repeat a. and d. using sugar as the solute.

f. Graph the results recorded to compare the solubilities of sugar and salt at different temperatures.

Step Four: Gathering Data

Record your results on the appropriate chart in Step Five.

Step Five: Processing Data

8. Record your data in the following charts.

a.

Water Temperature (°C)	Solubility of Salt (tablespoons/100 mL)

b.

Water Temperature (°C)	Solubility of Sugar (tablespoons/100 mL)

9. Use your charts to construct two curves on the following graph. Label each curve.

Title: ______________________________

Step Six: Interpreting Data

10. Explain what your graphs tell you about the solubilities of the two solutes you experimented with.

Check your answers with your learning facilitator.

There are limits to many things. An elastic can only stretch so far. You can only run so far. Water can dissolve only so much salt, baking soda, and sugar at a particular temperature.

Crystal-growing is a fascinating but generally slow process. Some crystals can take years to form. Some of the saturated solutions you made with hot water in this activity could grow crystals. Perhaps you would like to try to grow your own crystals.

Follow-up Activities

If you had difficulty understanding the concepts in the activities of this section, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

An example of concentration is 2.5 tablespoons of sugar in 100 mL of water. To measure concentration, determine the amount of solute that can be dissolved in 100 mL of solvent.

Solute solubility usually increases with a rise in temperature. Solubility is the measure of the maximum amount of substance that will dissolve in a given volume of solvent at a given temperature.

When water holds all of the sugar that it can hold, you can say that the water is saturated with sugar. The saturation point in a solution is reached when the solvent can hold no more solute.

Water Temperature (°C)	Solubility of Potassium Chloride (g/100 mL)
10	31
20	34
30	37
40	40

Use the preceding chart to answer the following questions.

1. What is the solubility of potassium chloride at 30°C? Be sure to include solubility units and temperature.

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2. Give an example of a concentration for potassium chloride that has not reached the saturation point. Be sure to include solubility units and temperature.

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Science inquiry studies cause and effect. The manipulated variable in an experiment is the factor that the scientist changes. It is the cause of the experiment. When you are doing an inquiry experiment, you are the scientist.

The responding variable in an experiment is the effect that the manipulated variable causes. It is nature's response to the scientist's manipulation.
A controlled variable is a factor that could change but is not allowed to change in an inquiry experiment.

In an experiment there can only be one manipulated variable and one responding variable. Usually there is more than one controlled variable that must be prevented from changing.

Refer to the solubility chart for potassium chloride to answer the following questions.

3. What are the manipulated and responding variables shown?

4. What controlled variable is very important to consider in determining temperature's effect on the solubility of potassium chloride?

You must remember a number of rules when you are graphing. A summary of these rules is given.

- The graph must have a title.
- The horizontal axis is reserved for the manipulated variable.
- The responding variable belongs on the vertical axis.
- The graph must include the manipulated and responding variable names on the appropriate axis. The units for each variable are written in brackets after each name.
- The plotted points on the graph should be circled.
- The plotted points must be connected with a straight line or smooth curve.
- Your graph must cover at least half of your graph paper.

5. Using these graphing rules and the data table, complete the following graph.

Water Temperature (°C)	Solubility of Potassium Chloride (g/100 mL)
10	31
20	34
30	37
40	40

Title: ______________________________

Check your answers with your learning facilitator.

Enrichment

1. In this section you made a graph following a set of rules.
   What were the rules you had to follow to graph your data?

2. Sodium sulfate has an unusual solubility curve. Using the graphing rules and the data table, graph the solubility of sodium sulfate.

Water Temperature (°C)	Solubility of Sodium Sulfate (g/100 mL)
0	3
10	10
19	20
32	40
35	49
50	46
60	45
70	44

Title: ____

Check your answers with your learning facilitator.

Conclusion

In this section you learned the following concepts:

- Concentration is the amount of solute in a given volume of solvent.
- A solution reaches its saturation point when no more solute will dissolve.
- Solubility is the measure of the maximum amount of solute that can dissolve in a solvent at a particular temperature.
- When doing a science inquiry you must be aware of three kinds of variables: the manipulated variable is the change that a scientist makes; nature's reaction to this change is called the responding variable; and controlled variables are factors that could change but must not be allowed to change in a scientific experiment.
- Graphing appropriate experimental results can make the interpretation of results simpler.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

MODULE SUMMARY

Matter can be pure substances or mixtures. Pure substances are rarely found. Most matter you are familiar with is a mixture.

Mixtures can be heterogeneous or homogeneous. Homogeneous mixtures (solutions) have indistinguishable parts. Parts are distinguishable in heterogeneous mixtures.

In this module, homogeneous liquid solutions were the focus. Liquid solutions are clear. In particular, aqueous solutions were used in most activities. Nonaqueous solutions were discussed briefly.

Mixtures can be natural or human-made. The air and oceans are examples of natural mixtures. Sugar water and brass are examples of human-made mixtures.

Heterogeneous mixtures may be separated by settling or filtration. Homogeneous mixtures cannot be separated by either method. Evaporation, distillation, and crystallization can be effective in separating solutions.

There is a limit to the amount of solute that will dissolve in a solvent. The measure of this limit is called solubility. Solubility can be measured when the concentration of a solution reaches its saturation point. Solubility generally increases when the temperature is increased.

Science inquiry depends on variables. The manipulated and responding variables determine the problem. The controlled variables help determine what procedures will be followed during the experiment.

Appendix

Glossary

Aqueous solution	• a solution in which water is the solvent
Boiling point	• temperature at which a liquid turns to a gas
Classify	• to organize objects into groups
Concentration	• the measure of the amount of solute that is in a given volume of solvent
Controlled variables	• factors that could change but are not allowed to change during a science inquiry experiment
Crystallization	• a process where solute comes together in a predictable pattern when the solvent evaporates
Crystals	• solids with distinct shapes and flat surfaces
Dissolving	• two substances combining so that they appear as only one substance
Distillate	• the liquid collected during distillation
Distillation	• the process in which a liquid is evaporated and collected
Evaporation	• the process in which a liquid changes to a gas
Freezing point	• the temperature at which a liquid turns to a solid
Heterogeneous mixture	• a mixture that does not form a solution The solute is insoluble. The solute does not dissolve in the solvent.
Homogeneous mixture	• a solution which has a solute The solute dissolves in the solvent.
Human-made	• manufactured by people
Insoluble	• unable to dissolve

Manipulated variable	• the factor that you, the scientist, change
Matter	• something that has mass and occupies space
Mechanical mixture	• another name for a heterogeneous mixture
Mechanical movement	• stirring or shaking
Mixture	• a substance that is made up of more than one kind of matter
Natural	• not made by people
Nonaqueous solution	• a solution in which water is not present
Physical appearance	• what something looks like For example, size, shape, and colour are familiar examples of physical appearance.
Pure substance	• a substance that contains only one kind of matter
Residue	• the matter that remains following distillation or filtration
Responding variable	• nature's response to changes that a scientist makes
Saturation point	• the point when no further solute can dissolve in a solution
Solubility	• the measure of the maximum amount of solute that will dissolve in a solvent at a given temperature
Soluble	• having the ability to dissolve
Solute	• the substance that dissolves in a solvent to make a solution
Solution	• what is formed when one substance dissolves in another
Solvent	• the substance that dissolves a solute to form a solution

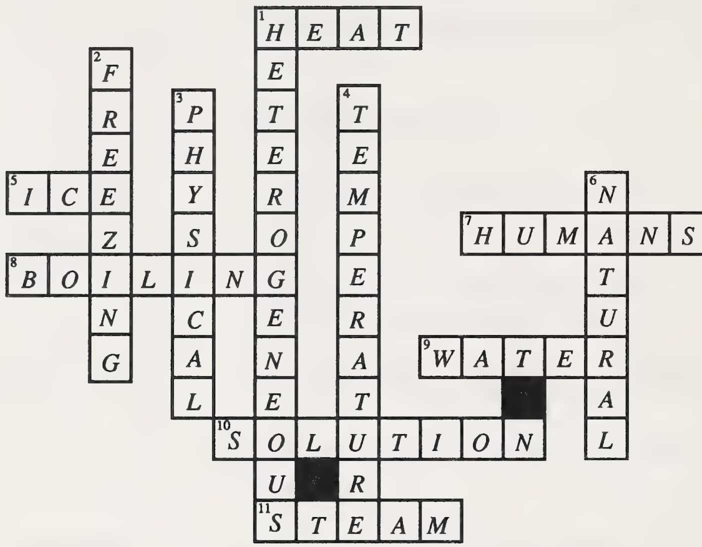
Steam
- the gaseous form of water; it can also be called water vapour

Variables
- the factors that can change in an experiment

Suggested Answers

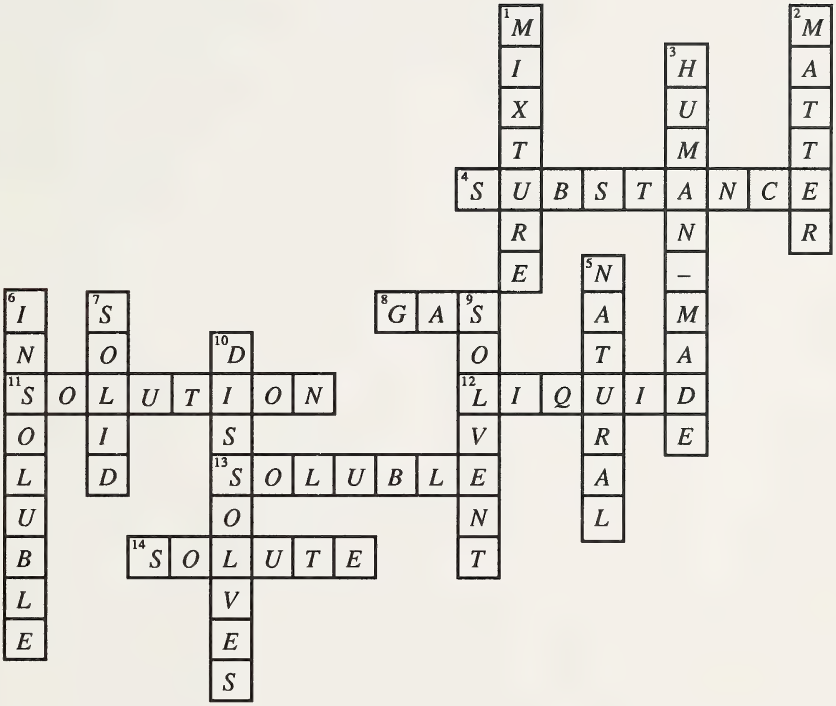
Section 1: Activity 3

8. The following puzzle will give you an opportunity to review many of the new terms you have learned in this module. Complete the puzzle.



Section 1: Activity 4

1. Complete the following puzzle.



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